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Original Article

The Intramuscular Course of the Greater Occipital Nerve: Novel Findings with Potential Implications for Operative Interventions and Occipital Neuralgia

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Abstract

Background: A better understanding of the etiologies of occipital neuralgia would help the clinician treat patients with this debilitating condition. Since few studies have examined the muscular course of the greater occipital nerve (GON), this study was performed.

Methods: Thirty adult cadaveric sides underwent dissection of the posterior occiput with special attention to the intramuscular course of the GON. Nerves were typed based on their muscular course.

Results: The GON traveled through the trapezius (type I; *n* = 5, 16.7%) or its aponeurosis (type II; *n* = 15, 83.3%) to become subcutaneous. Variations in the subtrapezius muscular course were found in 10 (33%) sides. In two (6.7%) sides, the GON traveled through the lower edge of the inferior capitis oblique muscle (subtype a). On five (16.7%) sides, the GON coursed through a tendinous band of the semispinalis capitis, not through its muscular fibers (subtype b). On three (10%) sides the GON bypassed the semispinalis capitis muscle to travel between its most medial fibers and the nuchal ligament (subtype c). For subtypes, eight were type II courses (through the aponeurosis of the trapezius), and two were type I courses (through the trapezius muscle). The authors identified two type IIa courses, four type IIb courses, and two type IIc courses. Type I courses included one type Ib and one type Ic courses.

Conclusions: Variations in the muscular course of the GON were common. Future studies correlating these findings with the anatomy in patients with occipital neuralgia may elucidate nerve courses vulnerable to nerve compression. This enhanced classification scheme describes the morphology in this region and allows more specific communications about GON variations.

Key Words: Anatomy, muscle, nerves, occiput, pain syndromes, skull

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INTRODUCTION

In 2004, the International Headache Society[8](IHS) listed more than 100 subtypes of headache and described occipital neuralgia as a paroxysmal stabbing pain in the sensory distribution of the greater, lesser, or third occipital nerves, sometimes accompanied by dysaesthesia of the affected region. The IHS further listed diagnostic criteria, including tenderness over the affected nerve and relief by local nerve injections. However, the latter two criteria can challenge the clinician because many variations in the pathway of these nerves have been described[2,4,12,14,15]and standard anatomical texts differ on the subject.

Most commonly associated with occipital neuralgia is the greater occipital nerve (GON). The GON originates from the medial branch of the dorsal ramus of spinal nerve C2. After coursing backwards between the first and second vertebrae, the GON ascends between the inferior capitis oblique and the semispinalis capitismuscles.[11]The GON is then described as piercing the trapezius or its aponeurosis inferolateral to the external occipital protuberance (EOP) and then ascending subcutaneously in a more or less vertical course to the skin overlying the vertex of the skull.

Most anatomic studies have focused on the subcutaneous course of the GON and its relationship to surrounding bony landmarks. As there is a lack of studies focused on the intramuscular course and relation of this nerve, the current study was undertaken with the hope of better understanding the anatomy of the nerve and potentially adding to our knowledge of its musculofibrous relationships in patients with occipital neuralgia. Additionally, since occipital neuralgia may occur after surgery of the upper cervical spine or posterior skull,[5] additional anatomic knowledge of the muscular relationships of the GON may alert the surgeon to this nerve's intramuscular variations.

MATERIALS AND METHODS

While placed in the prone position, 15 adult formalin fixed cadavers (30 sides) underwent dissection of the bilateral posterior occiput with special attention to the intramuscular course of the GON. Ten specimens were male and five were female, with an average age at death of 72 years (range 44–90 years). No specimen was found to have had prior surgery or gross injury to the areas dissected. After removing the skin, we identified the nerves above the EOP and followed them deeply through succeeding muscle layers while documenting the exact relationship and point of emergence through these layers. Each nerve was followed deep to the inferior border of the suboccipital triangle. Nerves were typed based on their muscular course.

RESULTS

A GON was identified in all specimens. In general, the GON wrapped around the lower edge of the inferior capitis oblique muscle and ascended deep to the semispinalis muscle to pierce this muscle more superiorly near its attachment onto the occiput. At this point, the nerve traveled through the trapezius (type I; n = 5, 16.7%) or its aponeurosis (type II; n = 15, 83.3%) to become subcutaneous inferolateral to the EOP [Figure 1]. The nerves then coursed superolaterally over the posterior occiput to a point near the vertex of the skull. Variations in the subtrapezius muscular course were found in 10 (33%) sides. On two (6.7%) sides (one left and one right), the GON traveled through the lower edge of the inferior capitis oblique muscle (subtype a)[Figure 1 left]. On five (16.7%; one left and four right) sides, the GON coursed through a horizontally positioned tendinous band (intersection) of the semispinalis capitis and not through its muscular fibers (subtype b) [Figure 1]. Many (12 of 27 sides) exit sites through the semispinalis capitis muscle in the same cadaver were found to be asymmetrical [Figures 1-5]. On three(10%) sides (one left and two right), the GON did not pierce the semispinalis capitis muscle, but bypassed this muscle to travel between its most medial fibers and the nuchal ligament (subtype c). For subtypes, eight were type II courses (through the aponeurosis of the trapezius) and two were type I courses (through the trapezius muscle)[Figures 1-5]. Specifically, we identified two type IIa courses, four type IIb courses, and two type IIc courses. For type I courses, there was one type Ib and one type Ic courses.

DISCUSSION

The IHS[8]noted in 2004 that it is important to differentiate occipital neuralgia from referred pain from the atlantoaxial or upper zygapophyseal joints, as well as from tender trigger points in the neck muscles and their bony insertions. Pathologies that may irritate or damage the GON include cervical trauma, iatrogenic injury during surgery, C2 osteophyte formation, C2 arthritis, cervical cord tumors, or Chiari malformation.[15]

In 1991, Bovim *et al*.[2]performed an investigation on 20 cadavers and found that the GON penetrated the trapezius muscle in 45% of cases, semispinalis capitis in 90%, and inferior capitis oblique in 7.5%. They found the GON prone to fibrous compression under the trapezius insertion. A cadaveric study by Bogduk[1]presented contrasting findings. The authors found that the GON did not pierce the trapezius; instead, it emerged through an aperture above the aponeurotic sling between the trapezius and the

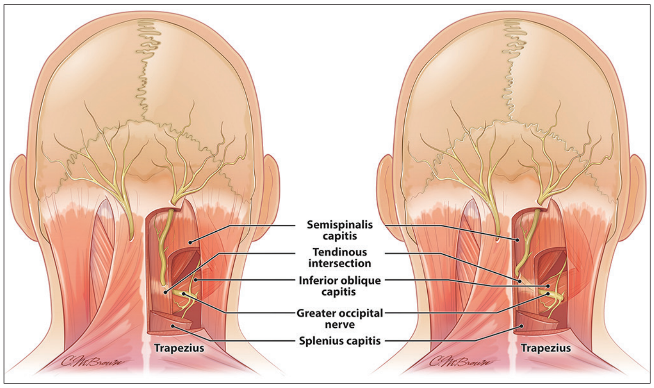

Figure 1: Schematic drawing of the GON in the occipital region. Note that the various muscular relationships with the GON, including an exit through the aponeurosis of the trapezius (right sides and type I GON), exit through the muscle of the trapezius (left sides and type II GON), exit through the tendinous intersection-left image/right side (type IIIa), and exit medial to the semispinalis capitis muscle-right image/right side (type III). Also, note that on the left figure, the GON pierces the inferior oblique muscle before ascending through the overlying muscles

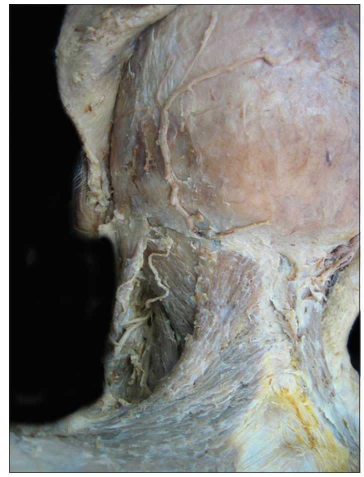

Figure 2: Left GON exiting through the aponeurosis of the trapezius (type I). For reference, note the left occipital artery traveling over the occiput just lateral to the GON

Figure 3: Type II GON is shown on the left exiting the muscle fibers of the trapezius muscle

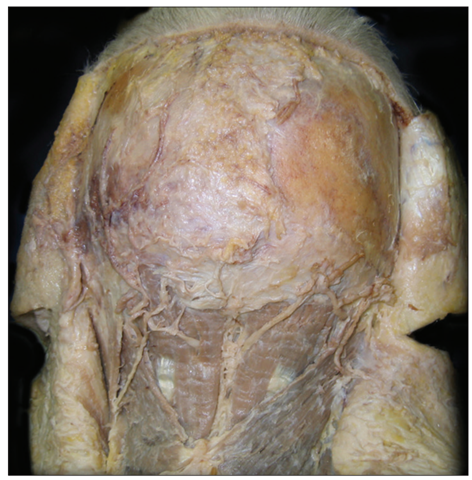

Figure 4: With removal of the trapezius, the right GON is seen bypassing the semispinalis capitis muscle (type III). For comparison, observe the left GON piercing the semispinalis capitis muscle

Figure 5: Type IIIa GON is seen on the right side of this dissection. Note the GON on the right traveling through the tendinous intersection of the semispinalis capitis muscle. For comparison, the left GON is seen exiting the semispinalis capitis muscle above its tendinous intersection

sternocleidomastoid. Furthermore, the authors stated that contraction or spasm of the trapezius, the mechanism cited by others for causing occipital neuralgia, would in fact draw this aponeurotic bridge downward and away from the GON, and hence, would not cause compression. Mosser *et al*.[12] found that the GON pierced the semispinalis capitis in 100% of their cases and little or no muscular involvement through the trapezius, and they reasoned that the trapezius was not a likely source of compression and that the transmuscular course through semispinalis capitis was the most likely source of potential irritation or compression. Güvençer *et al*.[5] published a cadaveric study and concluded that the GON can be compressed at specific points, including the point where it pierces the semispinalis capitis muscle, the point where it pierces the aponeurosis of trapezius, and finally, the point where it passes under the inferior capitis oblique.

Similar conclusions were made by other authors.[7,14,16] We found that the GON pierced the trapezius fascia and semispinalis muscle on the majority of sides and the inferior capitis oblique on two sides. On 16.7% of sides, the GON did not pierce the muscular fibers of the semispinalis muscle, but traversed its tendinous intersections.

Janis *et al*.[10]reported that 62% of their patients with occipital neuralgia had total relief after open release of GON entrapment. Ducic *et al*.[4]made intraoperative and cadaveric measurements and observations of the GON and reported an intraindividual variation seen as asymmetry in 43.9%. Of particular note is that the authors found that with increased chronicity of symptoms in patients with occipital neuralgia, the nerves had a yellowish-brown appearance, lacked blood vessels on their surface, and tended to lack a fascicular pattern. Muscular compression of the cutaneous nerves of the head resulting in pain has been reported.[6,7,9]In support of a muscular compression of the GON as a cause of occipital neuralgia and using ultrasound, Cho *et al*.[3]found significant differences in the cross-sectional area of the GON in patients with occipital neuralgia.

Topographically, Mosser *et al*.[12]concluded that there is a region located 1.5 cm in diameter centered 3 cm below and 1.5 cm lateral to the EOP, which reliably corresponds to the location where the GON emerges from the underlying semispinalis capitis. Natsis *et al*.[13]recommended injections at a site 2-2.5 cm below the EOP and about 1.5 cm laterally. Thus, this area would overlap with that recommended by Mosser *et al*.[12]Ducic *et al*.[4]placed the emergence of the GON from semispinalis capitis on average at 1.49 cm lateral and 3.02 cm inferior to the EOP. Tubbs *et al*.[15]found the GON lying on average 4 cm lateral to the EOP and 2 cm superior to an intermastoid line. In addition, they found the GON to branch into the medial and lateral branches on average 0.5 cm above the EOP.

CONCLUSIONS

Variations in the muscular course of the GON were often seen in our study. Future studies aimed at correlating these anatomic findings with the anatomy found in patients with occipital neuralgia may elucidate potential nerve courses that are more prone to nerve compression. Furthermore, the classification scheme described herein better describes the morphology in this region and will allow for more specific communication of variations of the muscular course of the GON.

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REFERENCES

1. Bogduk N. The clinical anatomy of the cervical dorsal rami. Spine 1982;7:319-30.
2. Bovim G, Bonamico L, Fredriksen TA, Lindboe CF, Stolt-Nielsen A, Sjaastad O. Topographic variations in the peripheral course of the greater occipital nerve. Autopsy study with clinical correlations. Spine 1991;16:475-8.
3. Cho JC, Haun DW, Kettner NW. Sonographic evaluation of the greater occipital nerve in unilateral occipital neuralgia. J Ultrasound Med 2012;31:37-42.
4. Ducic I, Moriarty M, Al-Attar A. Anatomical variations of the occipital nerves: Implications for the treatment of chronic headaches. Plast Reconstr Surg 2009;123:859-63.
5. Guvencer M, Akyer P, Sayhan S, Tetik S. The importance of the greater occipital nerve in the occipital and the suboccipital region for nerve blockade and surgical approaches-an anatomic study on cadavers. Clin Neurol Neurosurg 2011;113:289-94.
6. Guyuron B, Varghai A, Michelow BJ, Thomas T, Davis J. Corrugator supercilii muscle resection and migraine headaches. Plast Reconstr Surg 2000;106:429-34.
7. Hammond SR, Danta G. Occipital neuralgia. Clin Exp Neurol 1978;15:258-70.
8. Headache Classification Subcommittee of the International Headache Society. The International Classification of Headache Disorders: 2nd edition. Cephalalgia 2004;24 Suppl 1:9-160.
9. Hunter CR, Mayfield FH. Role of the upper cervical roots in the production of pain in the head. Am J Surg 1949;78:743-51.
10. Janis JE, Hatef DA, Reece EM, McCluskey PD, Schaub TA, Guyuron B. Neurovascular compression of the greater occipital nerve: Implications for migraine headaches. Plast Reconstr Surg 2010;126:1996-2001.
11. Kemp WJ 3rd, Tubbs RS, Cohen-Gadol AA. The innervation of the scalp: A comprehensive review including anatomy, pathology, and neurosurgical correlates. Surg Neurol Int 2011;2:178.
12. Mosser SW, Guyuron B, Janis JE, Rohrich RJ. The anatomy of the greater occipital nerve: Implications for the etiology of migraine headaches. Plast Reconstr Surg 2004;113:693-7.
13. Natsis K, Baraliakos X, Appell HJ, Tsikaras P, Gigis I, Koebke J. The course of the greater occipital nerve in the suboccipital region: A proposal for setting landmarks for local anesthesia in patients with occipital neuralgia. Clin Anat 2006;19:332-6.
14. Sulfaro MA, Gobetti JP. Occipital neuralgia manifesting as orofacial pain. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1995;80:751-5.
15. Tubbs RS, Salter EG, Wellons JC, Blount JP, Oakes WJ. Landmarks for the identification of the cutaneous nerves of the occiput and nuchal regions. Clin Anat 2007;20:235-8.
16. Wang Y, Yu CY, Huang L, Riederer F, Ettlin D. Familial neuralgia of occipital and intermedius nerves in a Chinese family. J Headache Pain 2011;12:497-500.